

CLAIMS

What is claimed is:

1. A process for removing sulfur from a sulfur-containing hydrocarbon fuel comprising:
 - 5 contacting a hydrocarbon fuel in the absence of added hydrogen at a temperature in the range of 300 to 600°C and at a pressure in the range from about 790 kPa to about 3.5 MPa with a primary desulfurization agent to produce a reaction between the hydrocarbon fuel and the primary desulfurization agent that removes sulfur from the hydrocarbon fuel; and
 - 10 regenerating the primary desulfurization agent by exposing it to oxygen at a temperature in the range of 300 to 600°C.
2. The process of claim 1, further comprising the step of contacting the hydrocarbon fuel with an acidic inorganic material at a temperature in the range of 300 to 600°C and at a pressure in the range of about 790 kPa to about 3.5 MPa to effect a reduction in the average molecular weight of the hydrocarbon fuel.
- 15 3. The process of claim 2, wherein the acidic inorganic material is a zeolite.
4. The process of claim 3, wherein the acidic inorganic material is a mixture of H-ZSM-5 and H-Beta zeolites.
5. The process of claim 1, further comprising the step of separating a higher-boiling fraction and a lower-boiling fraction from the reaction product.
- 20 6. The process of claim 5, wherein the higher-boiling fraction and lower-boiling fraction are separated at a temperature in the range of 200 to 400°C and at a pressure in the range from about 100 kPa to about 2.9 MPa.
7. The process of claim 5, further comprising the step of contacting the lower-boiling fraction with a secondary desulfurization agent.

8. The process of claim 7, wherein the secondary desulfurization agent is a metal or metal oxide absorbent.

9. The process of claim 8, wherein the secondary desulfurization agent is Ni/Al₂O₃ or Cu/ZnO/Al₂O₃.

5 10. The process of claim 5, wherein the higher-boiling fraction derived is combusted to provide heat that is transported to the primary desulfurization agent.

11. The process of claim 5, wherein the higher-boiling fraction is recycled and passed through the desulfurization system a second time.

10 12. The process of claim 1, wherein the hydrocarbon fuel comprises gasoline, kerosene, diesel fuel, jet fuel, heating oil or combinations thereof.

13. The process of claim 1, wherein the hydrocarbon fuel includes sulfur at a concentration greater than 100 parts per million by weight.

14. The process of claim 1, wherein the hydrocarbon fuel contacts the primary desulfurization agent at a pressure in the range from about 1.5 MPa to about 2.5 MPa and 15 at a temperature in the range of 350°C to 475°C.

15. The process of claim 1, wherein organosulfur compounds in the hydrocarbon fuel are cracked to produce H₂S and cracked hydrocarbon products before or while the hydrocarbon fuel contacts the primary desulfurization agent.

16. The process of claim 1, wherein the primary desulfurization agent includes a metal or 20 metal oxide, wherein the metal is selected from the group of elements consisting of Fe, Co, Ni, Zn, Mo, W, and mixtures thereof, and wherein the metal or metal oxide is supported on an inorganic support.

17. The process of claim 1, wherein the primary desulfurization agent includes a metal or metal oxide, wherein the metal is selected from the group of elements consisting of Ti, V, Cr, Mn, Cu, Ga, Zr, Nb, Mo, Ag, In, Sn, Hf, Ta, W, Pb, and mixtures thereof, and wherein the metal or metal oxide is supported on an inorganic support.
- 5 18. The process of claim 1, wherein the primary desulfurization agent includes a metal or metal oxide, wherein the metal is selected from the group of elements consisting of Mo, W, and mixtures thereof, and wherein the metal or metal oxide is supported on an inorganic support.
- 10 19. The process of claim 1, wherein the primary desulfurization agent comprises MoO_3 .
20. The process of claim 19, wherein the MoO_3 is coated on an Al_2O_3 substrate.
21. The process of claim 20, wherein the primary desulfurization agent comprises:
 - 15-30 weight-% MoO_3 ; and
 - 70-85 weight-% of a combination of Al_2O_3 and another transition metal species.
- 15 22. The process of claim 20, wherein the primary desulfurization agent is 15-30 weight-% MoO_3 and 70-85 weight-% Al_2O_3 .
23. The process of claim 19, wherein the primary desulfurization agent comprises at least about 90% MoO_3 .
24. The process of claim 1, wherein the primary desulfurization agent is regenerated by exposing it to oxygen at 350 to 475°C.
- 20 25. The process of claim 1, wherein the primary desulfurization agent is regenerated by exposing it to oxygen at a temperature that is substantially the same as that at which the primary desulfurization agent removes sulfur from the hydrocarbon fuel.

26. The process of claim 1, wherein in the reaction between the hydrocarbon fuel and the primary desulfurization agent, the primary desulfurization agent abstracts sulfur from the hydrocarbon fuel.

27. The process of claim 1, wherein the amount of at least one of dibenzothiophene, alkyldibenzothiophene compounds and dialkyldibenzothiophene compounds in the hydrocarbon fuel is reduced by the process.

28. A process for removing sulfur from a sulfur-containing hydrocarbon fuel comprising:
contacting a hydrocarbon fuel in the absence of added hydrogen with a primary desulfurization agent comprising a transition metal oxide, wherein the primary desulfurization agent removes sulfur from hydrocarbons in the sulfur-containing hydrocarbon fuel via conversion of the transition metal oxide into a transition metal sulfide; and
regenerating the desulfurization agent by exposing it to oxygen to convert the transition metal sulfide back to a transition metal oxide.

29. The process of claim 28, wherein the conversion of the transition metal oxide into a transition metal sulfide and the conversion of the transition metal sulfide back into a transition metal oxide each occur at a temperature in the range from 300 to 600°C.

30. The process of claim 28, wherein the conversion of the transition metal oxide into a transition metal sulfide and the conversion of the transition metal sulfide back into a transition metal oxide each occur at a temperature in the range from 350 to 475°C.

31. The process of claim 28, wherein the hydrocarbons from which the sulfur is removed comprise at least one of dibenzothiophene, alkyldibenzothiophene compounds, and dialkylbenzothiophene compounds.

32. The process of claim 28, wherein the conversion of the transition metal oxide into a transition metal sulfide and the conversion of the transition metal sulfide back into a transition metal oxide each occur at substantially the same temperature.

33. The process of claim 28, wherein the transition metal oxide comprises a metal oxide selected from the group consisting of MoO_3 , Ta_2O_5 , WO_3 and combinations thereof.
34. The process of claim 28, wherein the metal oxide is MoO_3 .
35. An absorbent composition suitable for removal of sulfur from hydrocarbon fuels comprising 15 to 30 weight-% MoO_3 and 70 to 85 weight-% Al_2O_3 , and possessing a surface area greater than $150 \text{ m}^2/\text{g}$ and a pore volume greater than $0.45 \text{ cm}^3/\text{g}$.
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